The Influence of Sociodemographic and Technology-Associated Factors on Stress from Human Interaction with Electric Vehicle Information Systems

Full papers

Ilja Nastjuk
University of Goettingen
inastju@uni-goettingen.de

Simon Trang
University of Goettingen
strang@uni-goettingen.de

Lutz Maria Kolbe
University of Goettingen
lkolbe@uni-goettingen.de

Abstract

The purpose of this study is to examine the influence of technology-associated and sociodemographic factors on perceived stress resulting from human interaction with electric vehicle information systems. Referring to the transactional stress model of Lazarus and Folkman (1984), we propose a research model to determine the impact of technical affinity, familiarity with electric vehicles, experience with electric vehicle information systems, age, gender, and education on perceived electric vehicle information systems-related stress. We tested our conceptual model using data from a web-based questionnaire, incorporating responses from 225 participants. Using partial least squares structural equation modeling (PLS-SEM), our results demonstrate that the associations between perceived electric vehicle information systems-related stress and affinity for technology, experience with electric vehicle information systems, and education are negative and significant, while that with age is positive and significant.

Keywords

Stress, Electric Vehicles; Technostress, In-Vehicle Information Systems, Assistance Systems, Human-Computer Interaction

Introduction

The development of information systems (IS) in vehicles continues to advance steadily. In this context, the fully connected car is a subject of great interest not only to the automotive industry but also to various organizations, engineers, and researchers. Features such as convenience, communication, entertainment systems, vehicle-to-vehicle communication, intelligent navigation systems, or safety and collision-avoidance systems provide a wide range of information to the driver, thus enabling communication with the world outside the vehicle and ensuring comfortable and safe transport. As a result, IS have become unique selling points for automotive manufacturers, leading to steady improvement and new designs of in-vehicle IS, which in turn integrate vehicles more and more deeply into people's lives (Aissaoui et al. 2014; Bitner 2001; Brandt 2013).

However, despite the significant opportunities created by increasing IS in vehicles, interaction with technologies also poses a major challenge because it requires continually increasing daily interactions that may lead to serious negative psychological and physiological health impacts. In this context, the term technostress, defined as "a modern disease of adaptation caused by an inability to cope with the new computer technologies in a healthy manner" (Brod 1984), has garnered considerable interest within the IS community (e.g., Kupersmith 1992; Shu et al. 2011; Tarafdar et al. 2010; Tu et al. 2005). Ragu-Nathan et al. (2008) work out various factors that trigger the stress process caused by interaction with IS, such as permanent connectivity, simultaneously handling multiple streams of information, or the pressure to be up to date with the latest technology.

Prior research in the field of IS and stress has mostly centered on stress resulting from IS usage in organizations. In the context of electric or conventional vehicles, stress has predominantly been examined in terms of different resources while driving, because the process of driving is demanding, requiring high mental concentration and a vital balance between courtesy and calmness. This balance can be affected by driver stress, which can stem from various sources, such as fast-changing road conditions, dislike of driving, tension and frustration associated with unsuccessful overtaking, or irritation when overtaken (Gulian et al. 1989; Singh and Queyam 2013). In the particular case of electric vehicles (EVs), recent research has identified the short driving range as a new source of stress, conceptualized as a concern of becoming stranded with an empty battery due to the limited range in EVs (e.g., Eisel et al. 2014; Franke et al. 2012; Rauh et al. 2014).

However, the dimension of driver stress that can be triggered by interaction with IS in vehicles has faded almost completely from the spotlight in research, although there are a few indications in literature. Alm and Nielsson (1995), for example, point out that the use of mobile telephones while driving leads to a greater workload and restricts the driver's ability to interpret relevant information from the traffic scene, thereby leading to a possible increase in driver stress level. In the same direction, Schiessl (2007) argues that interaction with navigation systems leads to an increased workload and can thus trigger the stress process.

Given the research gap identified above, our paper aims to emphasize the potential threat resulting from interaction with electric vehicles information systems (EVIS) and investigates the effects of various personal factors on this type of stress. We therefore elaborate on the following research question: Are there differences in EVIS-related stress perception due to different sociodemographic (age, gender, educational level) and technology-associated (experience with EVs and EVIS) factors?

The paper is organized as follows: The next section explains the theoretical foundations of stress in the context of the transactional perspective, particularly elaborating upon the transactional stress model of Lazarus and Folkman (1984). Following this, we review the role of IS in the success of EVs. In the further course of this paper, we present and discuss our research model and methodological approach. The paper is then finalized with a discussion of our results and implications for further research.

Theoretical Background

Understanding Stress from a Transactional Perspective

As the term stress has been enjoying increasing popularity in various fields of research, a considerable body of definitions and concepts has emerged. There is therefore great ambiguity concerning a consistent definition, determined by the nature of stress as a composite, multidimensional concept comprising many different components (Cohen et al. 1997; Levine and Ursin 1991).

For our study, we conceptualize stress as "a particular relationship between the person and the environment that is appraised by the person as taxing or exceeding his or her resources and endangering his or her well-being" (Lazarus and Folkman 1984). Stress is a complex psychological process that is determined by specific appraisal processes, namely, primary appraisal, secondary appraisal, and reappraisal (Lazarus 1966; Lazarus and Folkman 1984). Figure 1 schematically illustrates Lazarus' transactional model of stress.

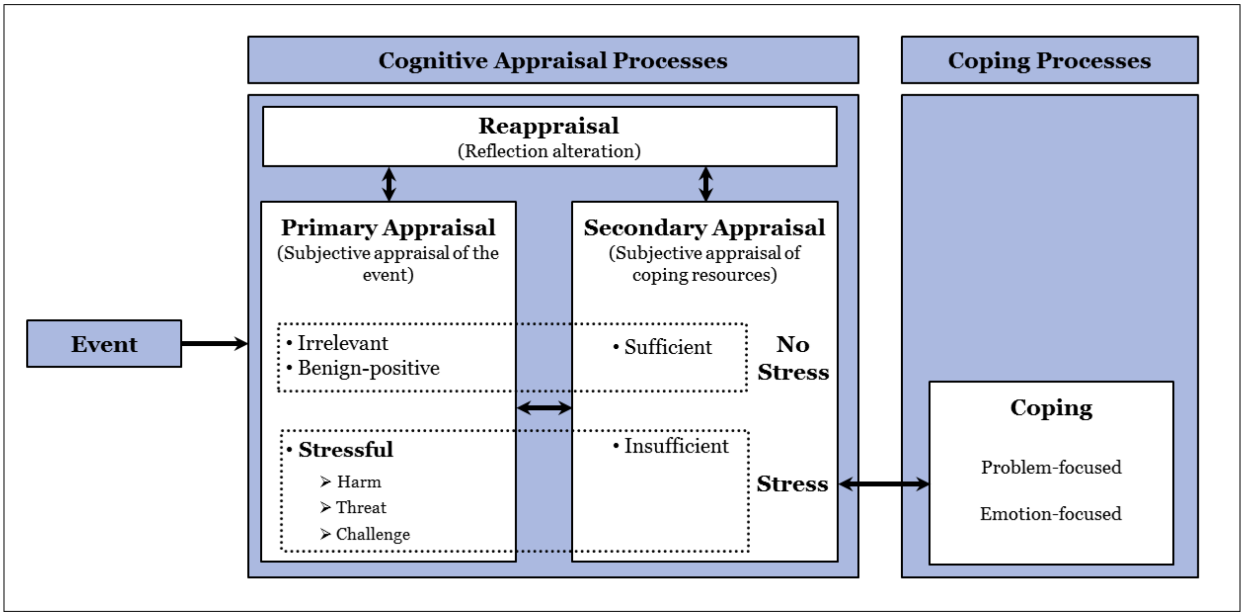

Figure 1. Transactional Stress Model of Lazarus and Folkman (1984)

Within the primary appraisal process, the individual determines whether an event is perceived as irrelevant, benign-positive, or stressful to one's well-being (Lazarus and Folkman 1984). In an irrelevant appraisal, the event has no impact on well-being. Events appraised as benign-positive, however, are evaluated as positive to well-being, often characterized by positive emotions, such as happiness or joy. Irrelevant or benign-positive appraisals do not trigger the stress process. If an event is appraised as stressful, it is seen as a challenge (demanding situations that the individual may overcome by effectively mobilizing personal resources), harm (damage that already occurred), or threat (anticipated threat that has not yet taken place but may negatively affect well-being). Generally, an event seen as a threat or harm is characterized by negative emotions such as anxiety or fright; in contrast, challenges can also trigger positive emotions such as hopefulness or eagerness (Lazarus 1993; Lazarus and Folkman 1984).

If individuals appraise events as stressful, the transactional model proposes that they will engage in secondary appraisal in order to overcome the stressful situation. This appraisal focuses on available coping options (Folkman et al. 1986). Jerusalem and Schwarzer (1989), for example, refer to material, personal, and social resources for altering the perceived threat, harm, or challenge.

According to Lazarus (1984), psychological stress results when an individual feels that their coping options are insufficient to manage the stressful event. Because psychological stress is characterized by an unfavorable person–environment relationship, individuals alter their circumstances to make them more favorable – a means referred to as coping efforts. These efforts affect psychological stress in two major ways: individuals either attempt to deal with the root of the stress (problem-centered coping) or try to regulate their emotions (emotion-centered coping) (Folkman et al. 1986; Lazarus 1993).

Finally, if there is any new stimulus that is appraised as relevant to the stress process, a reappraisal of the person–environment relationship may occur. For example, an event initially classified as harm may later be classified as irrelevant to one's well-being after receiving new information from the environment.

Assistance and Information Systems in Electric Vehicles

In a world where environmental challenges such as global warming or greenhouse gas emissions are a growing concern, the dissemination of EVs is considered to be crucial on the pathway to a sustainable future (Samaras and Meisterling 2008). The term *electric vehicle* is defined as any vehicle with electric propulsion, including battery electric vehicles (BEVs), hybrid electric vehicles, and fuel cell electric vehicles (Chan and Wong 2004). Drivers of BEVs are faced with challenges distinct from those faced by drivers of conventional vehicles, including lower range, long charging times, and insufficient charging infrastructure (Hidrue et al. 2011; Zhang et al. 2014). Consequently, EVs have begun to come to the forefront of information systems research (e.g., Brandt 2013; Eisel and Schmidt 2014; Ferreira et al. 2014).

IS has the potential to influence the behavioral trends related to adopting EVs by highlighting the value of IS in reducing the disadvantages associated with EV use (Busse et al. 2013). Generally, it is expected that, in the future, IS in electric vehicles will be used at a larger scale. For example, Internet in the car will not be accessible only via portable devices such as smartphones or tablets, but instead, future cars will be directly connected with the Internet (Abdelkafi et al. 2013; Dijk et al. 2013). Brandt (2013) proposes a categorization of EVIS according to the object the system provides information about: First, *convenience, communication, and entertainment systems* are IS that make traveling more comfortable and enjoyable by providing entertainment features to the driver (e.g., radio, TV, or car phone). Second, *geo IS and navigation* includes systems that provide information about the trip, such as current location, traffic situation, or road conditions. Traffic information systems and global positioning systems belong to this category. Third, *vehicle monitoring systems* measure and keep track of the various vehicle functions and provide the driver with information about the status of the car. Finally, *safety and collision avoidance systems* focus on the vehicle surroundings and help drivers prevent collisions. Safety features such as automatic braking assistance or parking sensors are part of this category. The evolution of intelligent IS in automobiles is continuing under the buzzword “connected car,” allowing people to access different kinds of services, such as booking rooms at a nearby hotels or making reservations at restaurants while on the road (Murphy et al. 2013; Swan 2015). However, besides the question of what relevant information content must be presented to EV drivers, the interface design – i.e., the way the information should be presented – is garnering increasing attention from researchers. For EVs, it comes down to the question of whether the in-vehicle instrument cluster should be designed in a traditional or innovative way in order to optimize the value of the presented information for the driver (Stroemberg et al. 2008).

Research Model and Hypotheses

Previous studies have identified typical sociodemographic characteristics, especially gender, educational level, and age, to be related to general stress (e.g., Fernandez et al. 2009; Burke and Mikkelsen 2005; Day and Livingstone 2003; Greenglass 2002; Gallo and Matthews 2003; Hall et al. 2006; Michael et al. 2009) and also to IS-related stress (e.g., Ragu-Nathan 2008). Using a computer-based task, Gotthard et al. (1995), examine the effects of aging and depression on stress-induced hypothalamic-pituitary-adrenal axis (HPA), showing a significantly larger cortisol response (physiological stress level) in older subjects. Other studies could not find any significant age-related changes in physiological responses, neither in women nor in men (Kudielka et al. 1999; Kudielka et al. 2000). However, in the work-related context, it has been established that age is negatively linked with stress; as people get older, they experience less stress (Michael et al. 2009). The relationship between stress and gender remains unclear (Kudielka et al. 2004; Michael et al. 2009). While a few studies have reported no significant gender difference, other reports have revealed significant differences (e.g., Collins and Frankenhaeuser 1978; Kirschbaum et al. 1995; Roxburgh 1996; Vermeulen and Mustard 2000; Martocchio and O'Leary 1989). Seeman (1995), for example, reveals that elderly women experience more stress compared to elderly men in a driving simulation task. Fernandes et al. (2009) investigate the differences of organizational role stress among male and female bank officers, finding that women experience more stress than men. However, in an investigation of male and female practitioners, Cooper et al. (1989) arrive at opposing results.

In summary, human studies investigating the impact of age and gender on stress offer conflicting predictions for the direction. Therefore, we highlight these inconsistences in the following pairs of hypotheses:

H1a: Age is positively associated with EVIS-related stress.

H1b: Age is negatively associated with EVIS-related stress.

H2a: Men perceive EVIS-related stress more than women.

H2b: Women perceive EVIS-related stress more than men.

Generally, researchers are in agreement that educational level has a negative relationship with occupational stress, as the higher the educational level, the lower the level of experienced stress (Gallo and Matthews 2003; Michael et al. 2009). Furthermore, it is expected that people who are more educated would be less anxious about learning how to use new information and communication systems (Ragu-Nathan et al. 2008). Finkelstein et al. (2007), for example, suggest that individuals with higher educational levels tend to be more optimistic and have more coping resources to handle stressful situations than individuals with lower education. For this reason, we expect that the more educated users would experience less EVIS-related stress.

H3: Educational level is negatively associated with EVIS-related stress.

Furthermore, we propose that technology-related characteristics influence EVIS-related stress, especially affinity for technology, experience with EVs, and experience with EVIS. Affinity for technology is defined by "the degree to which an individual likes or looks forward to learning about and being involved with new technology" (Geissler and Edison 2005). In their study on the value of IS for reducing perceived range stress, Eisel et al. (2014) emphasize the importance of affinity for technology when investigating stress. A further study revealed a significant positive relationship between affinity for technology and self-efficacy – an important coping construct in the stress process (Geissler and Edison 2005). However, individuals with a higher affinity for technology should perceive interaction with complex technology to be more pleasant than those with a low affinity. Accordingly, we hypothesize *H4*:

H4: Affinity for technology is negatively associated with EVIS-related stress.

Besides affinity for technology, we suggest that experience with EVIS influences the ability to handle complex technological systems and thus EVIS-related stress. Generally, people who have prior experience with similar technologies tend to perceive new technologies more positively and are therefore more motivated to become familiar with these technologies (Agarwal and Prasad 1999; Levin and Gordon 1989). Ragu-Nathan et al. (2008), for example, reveal that technostress decreases with increased computer confidence – a variable that is fostered by experience. Therefore, we assume that experience with EVIS leads to a decreased stress level:

H5: Experience with EVIS is negatively associated with EVIS-related stress.

We also propose that individuals with more EV experience perceive less EVIS-related stress, because interaction with EVs promotes interaction with EVIS. Following the same line of argumentation for *H5*, we propose *H6*:

H6: Experience with EVs is negatively associated with EVIS-related stress.

Figure 2 presents the research model for understanding the influence of sociodemographic and technology-associated factors on perceived EVIS-related stress. As mentioned in the previous chapter, EVIS-related stress results when an individual feels that their coping options (secondary appraisal) are insufficient to manage a stressful event (primary appraisal). A more precise classification of primary and secondary appraisal follows in the next chapter.

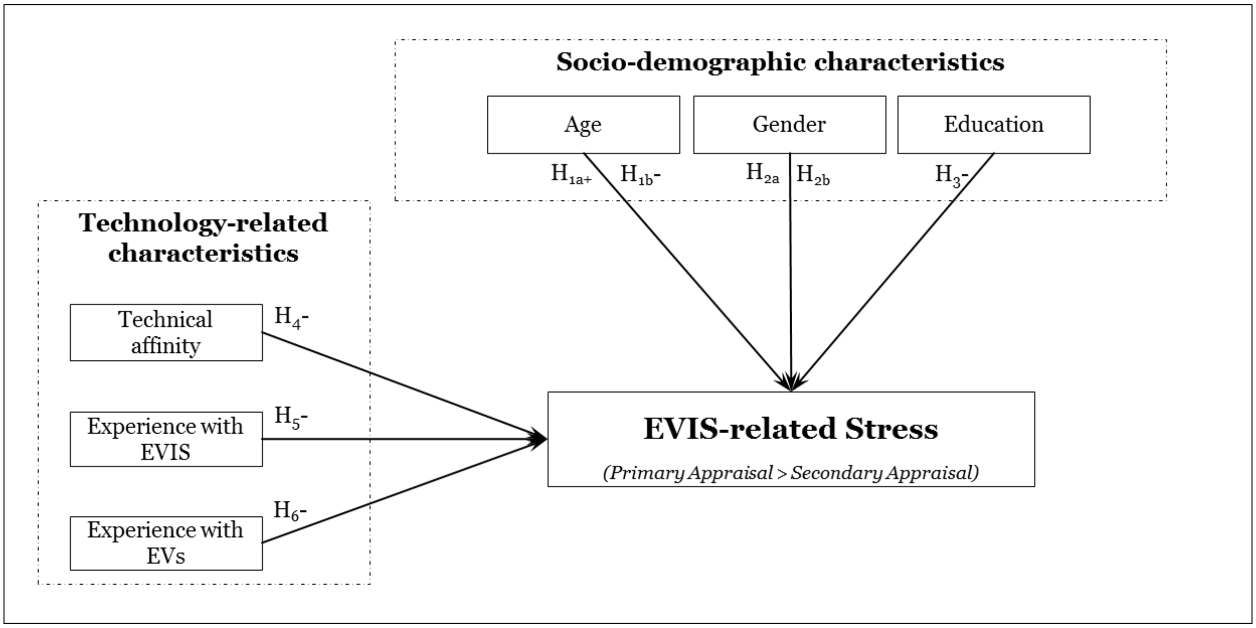

Figure 2. Research Model

Research Methodology

We designed and conducted a questionnaire-based study to empirically test our suggested hypotheses. To put the participants in the mindset of a potential EV user, the questionnaire first confronted the participants with a scenario in which they had to pick up a friend from a rail station 68 miles away. We then incorporated two different treatments in terms of the in-vehicle instrument provided. This allowed us to elicit greater variations in the stress construct. The description of each scenario comprised pictures of the EV's cockpit and additional information about the supportive IS. For the two scenarios, we applied and adjusted two different in-vehicle instrument clusters, as proposed by Stroemberg et al. (2008, pp. 179-180). While one concept was based on a traditional design that only provides information about speed, distance to empty, and state of charge, the other interface contained additional systems (e.g., Internet-based services, car-to-car communication, and various range calculations based on driving style). Participants were to imagine the respective situation with the goal of arousing a cognitive evaluation process (Rivkin and Taylor 1999; Zeimbekis 2011).

Measurement of Constructs

The Primary Appraisal Secondary Appraisal questionnaire (Gaab et al., 2005; Gaab 2009) refers to the transactional stress model of Lazarus (Lazarus and Folkman 1984) and therefore serves as a basis for measuring the construct "EVIS-related Stress". The proposed questionnaire assesses the primary and secondary appraisals, each with two subscales. While primary appraisal is measured with the scales *threat* and *challenge*, secondary appraisal is measured with the scales *self-concept of own abilities* and *control expectancy*. According to Lazarus and Folkman (1984), challenge refers to a demanding situation that the individual perceives as conquerable, whereas threat is related to anticipated harm or loss that may occur. Self-concept of own abilities refers to the individual's perception about oneself (Crocker and Major 1998). Internal locus of control is closely linked to control expectancy and describes the individual's perception of being in control of a certain event (Rotter 1966). All respective scales are operationalized by four items each, resulting in a 16-item questionnaire for assessing the EVIS-related stress construct. The questionnaire is based on a 6-point Likert scale ranging from 1 (strongly disagree) to 6 (strongly agree).

Furthermore, gender was recorded on a nominal scale as "male" or "female," while age was collected on a ratio scale. Educational level was measured on a 1 to 7 ordinal scale, with "1" corresponding to "high school dropout", "2-5" to certain country-specific types of secondary school or vocational qualifications, "5" to "general qualification for university entrance", "6" to "university degree", and "7" to "doctoral degree." Affinity for technology is operationalized by five items on a 7-point Likert scale, which were adopted and adjusted in our context from a previous study of Edison and Geissler (2003). Experience with EVs and EVIS are each operationalized by two items (in terms of knowledge and direct experience) on a 7-point Likert scale.

Data-Collection Procedure and Sample

We tested our research model with data collected from a web-based survey. The survey was run between November 2014 and January 2015. The subjects were recruited via social networks, certain car-focused websites, and direct acquisition. Before we conducted the survey we pre-tested the simulation design and questionnaire by interviewing researchers in the area of IS and stress, which led to minor changes in the wording of the scale and treatments. After excluding data sets due to quality criteria such as missing data or implausibility of demographics, we ended up with a total of 225 completed questionnaires. Of the respondents, 121 were women, with age ranging from 20 to 83. Four percent of the participants earned a Ph.D., 40% obtained a university degree, and 41.89% completed the A level. The remaining 14.11% had a lower level of education.

Data Analysis and Results

To test our research model, we rely on partial least squares structural equation modeling (PLS-SEM) using the software SmartPLS 2.0.M3 (Ringle et al. 2005). We decided to apply variance-based model estimation because PLS makes fewer demands regarding sample size, does not require normally distributed input data, and is especially useful for prediction (Urbach and Ahlemann 2010). The data analysis follows the widely adopted two-step approach to structural equation modeling suggested by Anderson and Gerbing (1988). In the first step, we assess the quality of the measurement model to ensure the reliability and validity of the instruments. In the second step, we analyze the structural model.

Measurement Validation

To assess the quality of the reflective constructs, we examined the content, convergent, and discriminant validities of the measures (Hair et al. 2012; Haynes et al. 1995). Content validity refers to the degree to which the measurement instruments are relevant to and representative of the target construct (Haynes et al. 1995). Since our underlying constructs and measures follow well-established theories and measures, we argue that content validity is given. Convergent validity refers to internal consistency and helps to assess whether indicators measuring a construct correspond with one another (Hulland 1999). It can be determined by calculating individual indicator reliability, composite construct reliability (CR), and average variance extracted (AVE), as suggested by Fornell and Larcker (1981). Due to low factor loadings, we dropped two items from the challenge scale. Afterwards, as shown in Table 2, all items loaded on their own constructs of .70 or higher, which implies an acceptable limit of indicator reliability (Hulland 1999). Furthermore, the CR varies above the acceptable limit of .70 (Hulland 1999) and all AVEs also exceeded the suggested limit value of .50 (Bhattacherjee and Premkumar 2004). Discriminant validity is described as the extent to which indicators of a given construct differ from indicators of other constructs in the same model (Hulland 1999). It is assessed by a more in-depth analysis of indicator correlations and AVE (Gefen and Straub 2005). Checking for cross-loadings, each indicator loaded on its assigned construct higher than on the other model constructs, implying that the indicator represents its assigned construct better than any other construct (Chin 1998). Moreover, we computed the square root of the AVEs. For each construct, this value is larger than any correlation with all other constructs, indicating discriminant validity (Fornell and Larcker 1981).

As mentioned in the *Measurement of Constructs* section, the stress construct comprises four subdimensions (two constructs each for primary and secondary appraisal). We therefore operationalized stress as a reflective-reflective second-order construct. Because all low-order constructs have the same number of indicators, we applied the indicator-reuse technique by conceptualizing primary appraisal and secondary appraisal as lower-order constructs of the higher-order construct “EVIS-related Stress” (Lohmöller 1989; Ringle et al. 2012).

Construct		Range	Mean	SD	CR	AVE	1	2	3	4	5	6	7	8	9	10
1	AGE	20-83	30.79	13.52	n.a.	n.a.	**n.a.**									
2	EDU	1-7	5.27	1.00	n.a.	n.a.	-.13	**n.a.**								
3	GEN	1-2*	1.54	0.50	n.a.	n.a.	-.06	.12	**n.a.**							
4	EXE	1-7	2.77	1.76	.91	.84	.09	.24	.30	**.95**						
5	EXI	1-7	2.69	1.72	.91	.84	.04	.26	.28	.74	**.96**					
6	TA	1-6	4.91	1.55	.95	.80	-.24	.42	.40	.50	.41	**.98**				
7	TC	1-6	3.59	1.09	.94	.89	.23	-.31	-.27	-.39	-.43	-.59	**.97**			
8	TL	1-6	2.70	1.22	.93	.76	.22	-.45	-.04	-.30	-.34	-.46	.52	**.96**		
9	TS	1-6	2.77	1.27	.94	.79	.26	-.40	-.26	-.41	-.45	-.61	.81	.63	**.97**	
10	TT	1-6	2.47	1.29	.92	.75	.24	-.34	-.18	-.37	-.37	-.53	.77	.59	.77	**.96**

AVE: average variance extracted; CR: composite reliability; SD: standard deviation; bolded numbers: square root of AVE; AGE:age; EDU: education; GEN: gender; EXE/EXI: experience with EVs/EVIS; TA: technical affinity; TC: techno-challenge; TC: techno-locus of control; TS: techno-self-concept; TT: techno-threat
** "1" refer to man*

Table 1. Mean, SD, CR, AVE, and Inter-Construct Correlations

	AGE	EDU	GEN	EXE	EXI	TA	TC	TL	TS	TT
AGE	**1.00**	.13	.06	.09	.04	.24	.23	.22	.26	.24
EDU	.13	**1.00**	.12	.24	.26	.42	.31	.45	.40	.34
GEN	.06	.12	**1.00**	.30	.28	.40	.27	.04	.26	.18
EXE01	.05	.26	.32	**.93**	.68	.50	.37	.28	.42	.36
EXE02	.12	.17	.21	**.90**	.68	.41	.34	.28	.32	.32
EXI01	.01	.27	.32	.71	**.92**	.41	.40	.32	.43	.33
EXI02	.08	.20	.20	.65	**.91**	.34	.40	.30	.38	.35
TA01	.31	.41	.34	.42	.31	**.92**	.59	.42	.59	.52
TA02	.31	.40	.29	.39	.32	**.89**	.55	.45	.59	.50
TA03	.13	.36	.43	.52	.41	**.91**	.51	.39	.53	.45
TA04	.08	.33	.39	.46	.39	**.84**	.48	.37	.50	.46
TA05	.20	.37	.36	.45	.39	**.90**	.49	.43	.51	.44
TC03	.20	.29	.24	.38	.42	.50	**.94**	.50	.75	.70
TC04	.23	.29	.26	.35	.39	.60	**.94**	.48	.77	.74
TL01	.13	.38	.04	.24	.31	.36	.47	**.90**	.54	.52
TL02	.12	.36	.05	.28	.30	.40	.47	**.92**	.56	.55
TL03	.24	.36	.03	.29	.34	.43	.43	**.91**	.55	.50
TL04	.30	.49	.01	.24	.21	.43	.46	**.76**	.56	.49
TS01	.23	.37	.27	.40	.46	.55	.80	.59	**.94**	.74
TS02	.20	.37	.22	.34	.35	.51	.72	.52	**.89**	.71

TS03	.22	.35	.19	.33	.37	.50	.71	.56	**.89**	.65
TS04	.26	.34	.23	.37	.39	.62	.63	.57	**.82**	.62
TT01	.14	.32	.13	.31	.31	.42	.59	.48	.61	**.81**
TT02	.19	.32	.14	.32	.31	.46	.59	.46	.62	**.84**
TT03	.22	.22	.17	.33	.32	.42	.68	.52	.66	**.89**
TT04	.28	.31	.17	.34	.33	.55	.78	.59	.77	**.93**

Bolded cells: indicator loadings; other cells: cross loadings

Table 2. Loadings and Cross-Loadings

Structural Model

To assess the structural path of the model, we used the bootstrapping procedure recommended in Chin (1998). We examined the significance of the regression parameter estimates using bootstrapping with n = 5000 samples (Hair et al. 2012). Applying a two-tailed t-test with a significance of 1% (5%; 10%), the path coefficient is significant if the critical t-value is larger than 2.58 (1.96; 1.65). Figure 3 presents the results of the structural model estimations. PLS regression analysis demonstrated that gender and experience with EVs did not verify the hypothesized effect on EVIS-related stress ($b = .07$, $p > 0.1$; $b = -.01$, $p > 0.1$). In contrast, the analysis revealed a significant negative effect of affinity for technology, experience with EVIS, and education on EVIS-related stress ($b = -.44$, $p < 0.01$; $b = -.0.25$, $p < 0.01$; $b = -.17$, $p < 0.01$) and a significant positive effect of age on EVIS-related stress ($b = .16$, $p < 0.05$). Overall, the model can explain 49.6% of the variance in EVIS-related stress, indicating an above-average explained variance (Chin 1998).

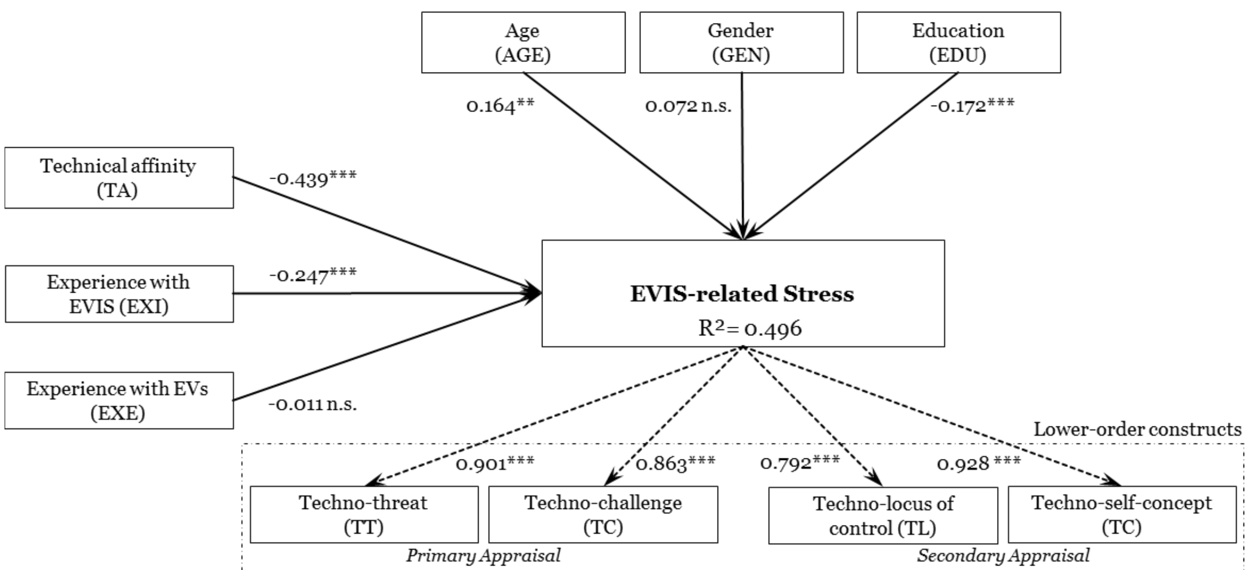

Figure 3. Results of the Structural Model Estimations

Discussion and Implications

Our results provide interesting findings for both research and practice. First, our results support our expectation that older people appraise EVIS-related stress higher than their younger counterparts. On the one side, this result is surprising because older people are expected to be more mature and therefore better able to handle stressors (Ragu-Nathan et al. 2008). On the other side, our hypothesized relationship is supported by the circumstance that older people are generally thought to be more averse to new technologies and consequently may experience more EVIS-related stress than younger people (Edison and Geissler 2003). This assumption is also supported by the study of Burton-Jones and Hubona (2005), which revealed that age negatively influences perceived ease of information and communication systems use. Second, our data did not reveal any significant influence of gender on perceived EVIS-related stress. This is in line with literature, which also reports no gender differences (e.g., Martocchio and O'Leary 1989; Roxburgh 1996). Third, the results indicate that EVIS-related stress decreases with a higher level of education. Individuals with higher educational levels tend to be less anxious about learning and using new information and communication systems while facing challenging situations with a higher degree of optimism (Finkelstein et al. 2007; Ragu-Nathan et al. 2008). Furthermore, educated people are able to mobilize more coping resources in order to handle stressful encounters. In this context, Eisel et al. (2014) report that the level of self-concept increases with a higher perceived ability to detect and carry out possible alternative actions. In addition, the appraisal processes in the transactional stress model are strongly influenced by the varying degree of information available. A lack of situation-related information hampers one's ability to precisely predict a certain situation and may therefore result in uncertainty and a higher level of perceived stress (Milliken 1987). Fourth, the results indicate that affinity for technology has a significant negative impact on perceived EVIS-related stress. Individuals with greater technical affinity perceive interaction with complex technologies to be more pleasant. Furthermore, there is a positive correlation between affinity for technology and the coping construct of self-efficacy. People with low self-efficacy tend to be uncertain about their ability to deal with new technologies and might even avoid them (Edison and Geissler 2003; Geissler and Edison 2005). This assumption is also supported by Shu et al. (2011), who show that people with higher computer self-efficacy tend to experience less technostress. Finally, the analyses indicate a significant negative relationship between experience with EVIS and EVIS-related stress. Generally, having prior experience with similar technologies strengthens the positive assessment of new technologies, thereby increasing motivation to interact with them (Agarwal and Prasad 1999; Levin and Gordon 1989). Furthermore, experience with EVIS supports processing confidence and helps in developing skills and knowledge for handling these systems, thus leading to a reduction of uncertainty and experienced stress (Holland et al. 2010; Lazarus and Folkman 1984). Ragu-Nathan et al. (2008) arrive at similar results, suggesting that technostress generally decreases with increasing technology experience. However, we could not support the assumed negative relationship between experience with EVs and experience with EVIS-related stress. This might be because most participants did not own an EV and were therefore short on EV experience.

With all findings taken together, practitioners should keep in mind that interaction with advanced automobile IS can lead to perceived stress and furthermore may be influenced by various sociodemographic and technology-related factors. These findings are especially interesting for the success of EVs, as a recent study by Eisel et al. (2014) revealed that perceived stress influences the attitude towards using an EV.

However, a few limitations to this study do exist and should be noted. First, the results are based on a specific type of EVIS. In order to confirm our findings, the influence of sociodemographic and technology-related factors on perceived EVIS-related stress should be investigated with further EVIS scenarios. Second, the self-report questionnaire approach is not free of certain response distortions (Razavi 2001). Further studies should consider additional assessment methods beyond the use of self-report questionnaires, including observations or biological measures (e.g., Riedl 2012). Finally, an experiment in a real life context is usually preferable to a mental treatment. Misinterpreted instructions, for example, might have had an effect on cognitive and affective arousals, and thereby on the results (Reips 2002). Thus, we suggest conducting a field experiment. Future research should also investigate further factors that create EVIS-related stress, such as dependence on technology, IS complexity, or information overload (Ragu-Nathan et al. 2008; Tarafdar et al. 2007).

Conclusion

The primary objective of this study was to emphasize a new dimension of driver stress in EVs, namely, EVIS-related stress. We therefore proposed a research model that investigates the influence of sociodemographic and technology-related factors on perceived EVIS-related stress. For hypotheses testing, we conducted a web-based survey. The results indicate that affinity for technology, experience with EVIS, and education are significant negatively and age significant positively associated with perceived EVIS-related stress.

REFERENCES

Abdelkafi, N., Makhotin, S., & Posselt, T. 2013. „Business model innovations for electric mobility—what can be learned from existing business model patterns?," International Journal of Innovation Management (17:01), pp. 1-41.

Agarwal, R., & Prasad, J. 1999. "Are individual differences germane to the acceptance of new information technologies?," *Decision sciences* (*30*:2), pp. 361-391.

Aissaoui, R., Menouar, H., Dhraief, A., Filali, F., Belghith, A., & Abu-Dayya, A. 2014. "Advanced real-time traffic monitoring system based on V2X communications," in *Proceedings of the International Conference on Communications (ICC)*, pp. 2713-2718.

Alm, H. and Nilsson, L. 1995. "The effects of a mobile telephone task on driver behaviour in a car following situation," *Accident Analysis & Prevention* (27:5), pp. 707-715.

Anderson, J. C., and Gerbing, D. W. 1988. „Structural equation modeling in practice: A review and recommended two-step approach," *Psychological bulletin* (*103*:3), 411-423.

Bhattacherjee, A., and Premkumar, G. 2004. "Understanding changes in belief and attitude toward information technology usage: a theoretical model and longitudinal test," *MIS quarterly* (28:2), pp. 229-254.

Bitner, M. J. 2001. "Service and technology: opportunities and paradoxes," *Managing service quality* (*11*:6), pp. 375-379.

Brandt, T., 2013. "Information Systems in Automobiles – Past, Present, and Future Uses," in *Proceedings of the Nineteenth Americas Conference on Information Systems*, Chicago, IL, Paper 1.

Brod, C. 1984. "Technostress: The Human Cost of the Computer Revolution," Boston, Massachusetts: Addison-Wesley.

Burke, R. J., and Mikkelsen, A. 2005. „Gender issues in policing: do they matter?," *Women in Management Review* (*20*:2), pp. 133-143.

Burton-Jones, A., and Hubona, G. S. 2005. "Individual differences and usage behavior: revisiting a technology acceptance model assumption," *ACM Sigmis Database* (*36*:2), pp. 58-77.

Busse, S., El Khatib, V., Brandt, T., Kranz, J., and Kolbe, L. 2013. "Understanding the Role of Culture in Eco-Innovation Adoption – An Empirical Cross-Country Comparison," in *Proceedings of the 34th International Conference on Information Systems*, Milan, Italy, Paper 6.

Chan, C. C. and Wong, Y. S. 2004. "Electric vehicles charge forward," *Power and Energy Magazine, IEEE* (2:6), pp. 24-33.

Chin, W. W. 1998. "The partial least squares approach to structural equation modeling," *Modern methods for business research* (*295*:2), pp. 295-336.

Cohen, S., Kessler, R. C. and Gordon, L. U. 1997. "Strategies for Measuring Stress in Studies of Psychiatric and Physical Disorders," in: *Measuring stress: A guide for health and social scientists*, S. Cohen, R.C. Kessler, and L.U. Gordon, Oxford: Oxford University Press, pp. 3-26.

Collins, A. and Frankenhaeuser, M., 1978. "Stress responses in male and female engineering students," *J. Human Stress* (4:2), pp. 43–48.

Cooper, C. L., Rout, U., and Faragher, B. 1989. "Mental health, job satisfaction, and job stress among general practitioners," *British Medical Journal* (*298*:6670), pp. 366-370.

Crocker, J. and Major, B. 1989. "Social stigma and self-esteem: The self-protective properties of stigma," *Psychological review (*96:4), pp. 608-630.

Day, A. L., and Livingstone, H. A. 2003. "Gender differences in perceptions of stressors and utilization of social support among university students," *Canadian Journal of Behavioural Science (35*:2), pp. 73-83.

Dijk, M., Orsato, R. J., and Kemp, R. 2013. "The emergence of an electric mobility trajectory," *Energy Policy* (*52)*, pp. 135-145.

Edison, S. W., and Geissler, G. L. 2003. "Measuring attitudes towards general technology: Antecedents, hypotheses and scale development," *Journal of Targeting, Measurement and Analysis for Marketing* (12:2), pp. 137–156.

Eisel, M. and Schmidt, J. 2014. "The Value of IS for Increasing the Acceptance of Electric Vehicles – The Case of Range Anxiety," in: *Tagungsband Multikonferenz Wirtschaftsinformatik*, Paderborn, Germany, pp. 882-894.

Eisel, M., Schmidt, J., Nastjuk, I., Ebermann, C. and Kolbe, L. 2014. „Can Information Systems Reduce Stress? The Impact of Information Systems on Perceived Stress and Attitude," in *Proceedings of the 35th International Conference on Information Systems*, Auckland, Australia, Paper 1.

Fernandes, C.F.V., Kumar, S., and M. Nandakumar. 2009. „Gender Differences in Stress among Bank Officers of Private and Public Sectors," *The IUP Journal of Organizational Behaviour* (April 2009), pp. 1-7.

Ferreira, J., Monteiro, V. and Afonso, J. 2014. "Vehicle-to-Anything Application (V2Anything App) for Electric Vehicles," *IEEE Transactions on Industrial Informatics* (10:3), pp. 1927-1937.

Finkelstein, M., Kubzansky, L.D., Capitman J., and Goodman, E. 2007. „Socioeconomic Differences in Adolescent Stress: The Role of Psychological Resources," *Adolescent Health* (40:2), pp. 127–134.

Folkman, S., Lazarus, R. S., Gruen, R. J. and DeLongis, A. 1986. "Appraisal, coping, health status, and psychological symptoms," *Journal of personality and social psychology* (50:3), pp. 571-579.

Fornell, C., & Larcker, D. F. 1981. "Evaluating structural equation models with unobservable variables and measurement error," *Journal of marketing research* (18:1), pp. 39-50.

Franke, T., Neumann, I., Bühler, F., Cocron, P. and Krems, J. F. 2012. "Experiencing range in an electric vehicle: understanding psychological barriers," *Applied Psychology* (61:3), pp. 368-391.

Gaab, J. 2009. "PASA–Primary Appraisal Secondary Appraisal," *Verhaltenstherapie* (19:2), pp. 114-115.

Gaab, J., Rohleder, N., Nater, U. M. and Ehlert, U. 2005. „Psychological determinants of the cortisol stress response: the role of anticipatory cognitive appraisal," *Psychoneuroendocrinology* (30:6), pp. 599-610.

Gallo, L. C., and Matthews, K. A. 2003. "Understanding the association between socioeconomic status and physical health: do negative emotions play a role?," *Psychological bulletin* (*129*:1), pp. 10-51.

Gefen, D., & Straub, D. 2005. "A practical guide to factorial validity using PLS-Graph: Tutorial and annotated example," *Communications of the Association for Information systems* (*16*:5), pp. 91-109.

Geissler, G. L., & Edison, S. W. 2005. "Market mavens' attitudes towards general technology: Implications for marketing communications," *Journal of Marketing Communications* (*11:*2), pp. 73-94.

Gotthardt, U., Schweiger, U., Fahrenberg, J., Lauer, C. J., Holsboer, F., and Heuser, I. 1995. „Cortisol, ACTH, and cardiovascular response to a cognitive challenge paradigm in aging and depression," *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology* (*268*:4), pp. 865-873.

Greenglass, E. R. 2002. "Work stress, coping, and social support: Implications for women's occupational well-being," in Gender work stress and health, D.L. Nelson and R.J. Burke (eds.), Washington, DC: American Psychological Association, pp. 85-96.

Gulian, E., Matthews, G., Glendon, A. I., Davies, D. R., Debney, L. M. 1989. "Dimensions of driver stress," Ergonomics (32:6), pp. 585–602.

Hair, J. F., Sarstedt, M., Ringle, C. M., and Mena, J. A. 2012. "An assessment of the use of partial least squares structural equation modeling in marketing research," *Journal of the Academy of Marketing Science* (*40*:3), pp. 414-433.

Hall, N. C., Chipperfield, J. G., Perry, R. P., Ruthig, J. C., and Goetz, T. 2006. "Primary and secondary control in academic development: gender-specific implications for stress and health in college students," *Anxiety, stress, and coping* (*19*:2), pp. 189-210.

Haynes, S. N., Richard, D., & Kubany, E. S. 1995. "Content validity in psychological assessment: A functional approach to concepts and methods," *Psychological assessment* (*7*:3), pp. 238-247.

Hidrue, M. K., Parsons, G. R., Kempton, W. and Gardner, M. P. 2011. "Willingness to pay for electric vehicles and their attributes," *Resource and Energy Economics* (33:3), pp. 686-705.

Holland, C., Geraghty, J., and Shah, K. 2010. "Differential moderating effect of locus of control on effect of driving experience in young male and female drivers," *Personality and Individual Differences* (*48:*7), pp. 821-826.

Hulland, J. 1999. "Use of partial least squares (PLS) in strategic management research: A review of four recent studies," *Strategic management journal* (*20*:2), pp. 195-204.

Jerusalem, M. and Schwarzer, R. 1989. "Anxiety and self-concept as antecedents of stress and coping: A longitudinal study with German and Turkish adolescents," *Personality and Individual Differences* (10:7), pp. 785-792.

Kirschbaum, C., Klauer, T., Filipp, S.-H., and Hellhammer, D.H., 1995. „Sex-specific effects of social support on cortisol and subjective responses to acute psychological stress," *Psychosom. Med.* (57), pp. 23–31.

Kudielka, B.M., Schmidt-Reinwald, A.K., Hellhammer, D.H. and Kirschbaum, C., 1999. „Psychological and endocrine responses to psychosocial stress and Dex–CRF in healthy postmenopausal women and young controls: the impact of age and a two-week estradiol treatment," *Neuroendocrinology* (70), pp. 422–430.

Kudielka, B.M., Schmidt-Reinwald, A.K., Hellhammer, and D.H., Kirschbaum, C., 2000. „Psychosocial stress and functioning of the hypothalamic–pituitary–adrenal axis: no evidence for a reduced resilience in elderly men," *Stress* (3:3), pp. 229–240.

Kupersmith, J. 1992. "Technostress and the reference librarian," *Reference Services Review* (20:2), pp. 7-50.

Lazarus, R.S., 1966. "Psychological Stress and the Coping Process," New York: McGraw-Hill.

Lazarus, R. S. 1993. "From psychological stress to the emotions: A history of changing outlooks," *Annual review of psychology* (44:1), pp. 1-22.

Lazarus, R. S. and Folkman, S. 1984. "Stress, appraisal, and coping," New York: Springer.

Levin, T., and Gordon, C. 1989. "Effect of gender and computer experience on attitudes toward computers," *Journal of Educational Computing Research* (5:1), pp. 69-88.

Levine, S. and Ursin, H. 1991. "What is stress?," in: *Stress: Neurobiology and neuroendocrinology*, M. R. Brown, G. F. Koob, and C. Rivier (eds.), New York: Marcel Dekker, pp. 3-21.

Lohmöller, J.-B., 1989 "Latent Variable Path Modeling with Partial Least Squares." Heidelberg: Physica.

Martocchio, J. J., and O'Leary, A. M. 1989. "Sex differences in occupational stress: A meta-analytic review," *Journal of Applied Psychology* (*74*:3), pp. 495-501.

Michael, G., Anastasios, S., Helen, K., Catherine, K., and Christine, K. 2009. "Gender differences in experiencing occupational stress: the role of age, education and marital status," *Stress and Health* (*25*:5), pp. 397-404.

Milliken J. F. 1987. "Three Types of Perceived Uncertainty About the Environment: State, Effect, and Response Uncertainty," *Academy of Management Review* (12:1), pp. 133-143.

Murphy, S., Nafaa, A., and Serafinski, J. 2013. "Advanced service delivery to the Connected Car," in *Proceedings of the 9th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob), Lyon, France*, pp. 147-153.

Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S. and Tu, Q. 2008. "The consequences of technostress for end users in organizations: Conceptual development and empirical validation," *Information Systems Research* (19:4), pp. 417-433.

Rauh, N., Franke, T. and Krems, J. F. 2014. "Understanding the impact of electric vehicle driving experience on range anxiety," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, pp. 1-11.

Razavi, T. 2001. "Self-Report Measures: An Overview of Concerns and Limitations of Questionnaire Use in Occupational Stress Research," *Working Paper from University of Southampton – Department of Accounting and Management Sciences*, Paper 01-175, pp. 1-23.

Reips, U. D. 2002. "Standards for Internet-based experimenting," *Experimental psychology* (49:4), pp. 243-256.

Riedl, R. 2012. "On the biology of technostress: literature review and research agenda," *ACM SIGMIS Database* (*44*:1), pp. 18-55.

Ringle, C. M., Wende, S., and Will, A. 2005. SmartPLS 2.0 (beta).

Ringle, C. M., Sarstedt, M., and Straub, D. 2012. "A critical look at the use of PLS-SEM in MIS Quarterly," *MIS Quarterly* (*36*:1), pp. iii-8.

Rivkin, I. and Taylor S. 1999. "The Effects of Mental Simulation on Coping with Controllable Stressful Events," Personality and social psychology bulletin (25), pp. 1451-1462.

Rotter, J. B. 1966. "Generalized expectancies for internal versus external control of reinforcement," *Psychological monographs: General and applied (*80:1), pp. 1-28.

Roxburgh, S. 1996. "Gender differences in work and well-being: Effects of exposure and vulnerability," *Journal of Health and Social Behavior* (37:3), pp. 265-277.

Samaras, C. and Meisterling, K. 2008. "Life cycle assessment of greenhouse gas emissions from plug-in hybrid vehicles: implications for policy," *Environmental science & technology* (42:9), pp. 3170-3176.

Schiessl, C. 2007. "Stress and strain while driving," in *Young Researchers Seminar (European Conference of Transport Research Institutes)*, Brno, Czech Republic, pp. 1-11.

Seeman, T.E., Singer, B. and Charpentier, P., 1995. "Gender differences in patterns of HPA axis response to challenge: MacArthur studies of successful aging," *Psychoneuroendocrinology* (20), pp. 711–725.

Shu, Q., Tu, Q., and Wang, K. 2011. „The impact of computer self-efficacy and technology dependence on computer-related technostress: A social cognitive theory perspective," *International Journal of Human-Computer Interaction* (*27*:10), pp. 923-939.

Singh, M. and Queyam, A. B. 2013. "Stress Detection in Automobile Drivers using Physiological Parameters: A Review," *International Journal of Electronics Engineering* (5:2), pp. 1-5.

Stroemberg, H., Andersson, P., Almgren, S., Ericsson, J., Karlsson, M. and Nåbo, A. 2011. „Driver interfaces for electric vehicles," in *Proceedings of the 3rd International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, Salzburg, Austria, pp. 177-184.

Swan, M. 2015. "Connected Car: Quantified Self becomes Quantified Car," *Journal of Sensor and Actuator Networks* (4:1), pp. 2-29.

Tarafdar, M., Tu, Q., Ragu-Nathan, B. S. and Ragu-Nathan, T. S. 2007. "The impact of technostress on role stress and productivity," *Journal of Management Information Systems (*24:1), pp. 301-328.

Tu, Q., Wang, K., and Shu, Q. 2005. "Computer-related technostress in China," *Communications of the ACM* (48:4), pp. 77-81.

Urbach, N., and Ahlemann, F. 2010. „Structural equation modeling in information systems research using partial least squares," *Journal of Information Technology Theory and Application* (*11*:2), pp. 5-40.

Vermeulen, M., and Mustard, C. 2000. "Gender differences in job strain, social support at work, and psychological distress," *Journal of occupational health psychology* (*5*:4), pp. 428-440.

Zeimbekis, J. 2011. "Thought experiments and mental simulations," in *Thought Experiments in Methodological and Historical Contexts*, K. Ierodiakonou and S. Roux, Leiden (eds.), Leiden: Brill, pp. 193-215.

Zhang, X., Rao, R., Xie, J. and Liang, Y. 2014. "The Current Dilemma and Future Path of China's Electric Vehicles," *Sustainability* (6:3), pp. 1567-1593.